# 20S-CHEM20B-1 Exam 1

AN LE

TOTAL POINTS

**174 / 175**

QUESTION 1

1 1 **15 / 15**

✓ **+ 15 pts Correct, $$ \Delta U = 11 J$$**

**+ 5 pts** $$w=\int Fdl = F \Delta l = 10 J$$

**+ 5 pts** $$q=mC_s\Delta T = 1J$$

**+ 5 pts** $$ \Delta U = q + w = 11J$$

**- 3 pts** Math or unit error

**+ 0 pts** Poor Scan/Did not follow instructions

QUESTION 2

2 20 pts

2.1 2.i **5 / 5**

✓ **+ 5 pts Correct $$w =0$$**

**- 3 pts** Math or unit error

**+ 0 pts** Incorrect

2.2 2.ii **14 / 15**

✓ **+ 10 pts Correct, $$ w=-374J$$**

**+ 4 pts** $$w=-\int P_{ex}dV = -P_{ex} \Delta V$$

**+ 4 pts** $$\Delta V = V_f-V_i \approx V_f$$

✓ **+ 4 pts $$w = -P_{ex} \Delta V =-nRT$$**

**+ 5 pts** $$w = \Delta U - q$$

**- 3 pts** Math or unit error

**+ 0 pts** Incorrect

QUESTION 3

3 30 pts

3.1 3.i **10 / 10**

✓ **+ 10 pts Correct, $$\Delta H_{r}^o = -896.3 \frac {kJ}{mol}$$**

**+ 2 pts** $$ \Delta H_{r}^o = \Delta H_{f}^o(products)-\Delta H_{f}^o(reactants) $$

**+ 3 pts** $$ \Delta H_{r}^o = [\Delta H_{f}^o(H_2O_{2(l)})+4\Delta H_{f}^o(N_{2(g)})]-[2\Delta H_{f}^o(HN_{3(l)})+2\Delta H_{f}^o(NO_{(g)})] $$

**+ 2 pts** $$\Delta H_f^o(N_{2(g)})=0$$

**- 3 pts** Math or unit error

3.2 3.ii **5 / 5**

✓ **+ 5 pts Correct, $$\Delta H_r^o<0$$, so exothermic**

**+ 3 pts** $$ \Delta H_r^o >0$$, so endothermic

3.3 3.iii **15 / 15**

✓ **+ 15 pts Correct, $$n_{NH_3}=0.046mol=0.04-0.05mol$$**

**+ 3 pts** $$q_r=n_r \Delta H_r^o$$

**+ 3 pts** $$q_w=mC_s \Delta T = 21 kJ$$

**+ 3 pts** $$ q_w = -q_r$$ or $$ q_w+q_r=0$$

**+ 3 pts** $$n_r=0.023mol=0.02mol$$

**- 3 pts** Math or unit error

QUESTION 4

4 4 **20 / 20**

✓ **+ 20 pts Correct, $$ T_{eq}=335K$$**

**+ 4 pts** $$q_i + q_w = 0$$ or $$ q_i = -q_w$$

**+ 5 pts** $$q_i = m_iC_i \Delta T_i + m_i \Delta H_{fus}^o + m_iC_w \Delta T_w$$

**+ 3 pts** $$q_i = m_iC_i  (273K-253K) + m_i \Delta H_{fus}^o + m_iC_w (T_{eq}-273K)$$

**+ 2 pts** $$ q_w = m_wC_w \Delta T$$

**+ 2 pts** $$ q_w = m_wC_w (T_{eq}-343K)$$

**- 3 pts** Math or unit error

QUESTION 5

5 40 pts

5.1 5.i **10 / 10**

✓ **+ 10 pts Correct, $$\Delta U_T = 0$$, $$q_T=nRTln(\frac {V_f}{V_i})$$, $$w_T=-nRTln(\frac**

{V_f}{V_i})$$

+ **3 pts** $$\Delta U_T = 0$$
+ **3 pts** $$q_T=nRTln(\frac {V_f}{V_i})$$
+ **4 pts** $$w_T=-nRTln(\frac {V_f}{V_i})$$

## 5.2 5.ii 20 / 20

✓ + **20 pts** **Correct, $$ \Delta U_V = \frac {3}{2}nR (T_2-T_i)$$, $$q_V= \frac {3}{2}nR (T_2-T_i)$$, $$w_V=0$$, $$ \Delta U_P = \frac {3}{2}nR (T_i-T_2)$$, $$q_P= \frac {5}{2}nR (T_i-T_2)$$, $$w_P=-P \Delta V=-nR (T_i-T_2)$$**

+ **4 pts** $$ \Delta U_V = \frac {3}{2}nR (T_2-T_i)$$
+ **3 pts** $$ q_V = \frac {3}{2}nR (T_2-T_i)$$
+ **3 pts** $$w_V=0$$
+ **4 pts** $$ \Delta U_P = \frac {3}{2}nR (T_i-T_2)$$
+ **3 pts** $$ q_P = \frac {5}{2}nR (T_i-T_2)$$
+ **3 pts** $$w_P=-P \Delta V=-nR (T_i-T_2)$$
- **2 pts** Answer not simplified or total process values not correct

## 5.3 5.iii 10 / 10

✓ + **10 pts** **Correct, $$ \Delta U_i=\Delta U_{ii}$$, $$q_i \ne q_{ii}$$, $$w_i \ne w_{ii} $$; $$q>0$$, so heat is being absorbed by the system; $$w<0$$, so work is being done by the system**

+ **3 pts** $$ \Delta U_i=\Delta U_{ii}$$, $$q_i \ne q_{ii}$$, $$w_i \ne w_{ii} $$
+ **4 pts** $$q>0$$, so heat is being absorbed by the system
+ **4 pts** $$w<0$$, so work is being done by the system
- **2 pts** $$q<0$$ or $$w>0$$ or $$w=0$$ or "it depends"
+ **2 pts** $$q>0$$, but no statement or incorrect statement of direction of exchange
+ **2 pts** $$w<0$$, but no statement or incorrect statement of direction of exchange
+ **2 pts** $$ \Delta U_i=\Delta U_{ii} = 0$$
+ **0 pts** Incorrect

QUESTION 6

# 6 50 pts

## 6.1 6.i 10 / 10

✓ + **10 pts** **Correct, CO is polar and has dipole-dipole forces, KF is ionic; therefore, KF IMFs are stronger.**

+ **3 pts** CO is polar $$ \Delta EN_{CO}=0.9$$ and has dipole-dipole IMFs
+ **3 pts** KF is ionic $$ \Delta EN_{KF}=3.16$$ and has ionic or strong dipole-dipole IMFs
+ **3 pts** KF > CO IMFs
+ **0 pts** poor scan/did not follow instructions

## 6.2 6.ii 10 / 10

✓ + **10 pts** **Correct**

+ **2 pts** Plot of $$ V(r) $$ vs $$ r $$
+ **2 pts** Correct general shape
+ **2 pts** KF has a deeper well because it has stronger IMFs
+ **2 pts** KF crosses the x-axis further from the origin because it is larger

## 6.3 6.iii 12 / 12

✓ + **12 pts** **Correct**

+ **3 pts** Plot of $$ P$$ vs $$ T $$
+ **3 pts** Correct shape
+ **2 pts** Point a: solid
+ **2 pts** Point b: The triple point, so solid, liquid and gas
+ **2 pts** Point c: The melting point, so solid and liquid

## 6.4 6.iv 10 / 10

✓ + **10 pts** **Correct, $$F=240.9kN=241kN$$**

+ **3 pts** $$r=0.62m$$
+ **2 pts** $$A=4.83m^2$$
+ **3 pts** $$ F=PA$$
- **3 pts** Math or unit error
+ **0 pts** No credit

## 6.5 6.v 8 / 8

✓ + **8 pts** **Correct, $$ V_{eq}=0.49m^3=0.5m^3$$**

+ **5 pts** At mechanical equilibrium, $$ P_{eq}=P_{atm}=1atm$$

- **3 pts** Math or unit error

Chem 20B Midterm 1 Exam

Name: An Le, UID:

Problem #1

1) $\Delta U = q + w$, $w = \int F dl$ ~~F = 1~~

$F = 100\ N$, $m = 1\ g = 0.001\ kg$, $\Delta T = 2\ K$, $l = 0.1\ m$, $C_s = 0.5\ J/g \cdot K$

$W = \int_0^{0.1} (100\ N)\, dl = 100 \int_0^{0.1} dl = 100 l \Big|_0^{0.1} = (100\ N)(0.1\ m)$

$W = 10\ J$

$q = nC_s \Delta T = (1 g)(0.5\ J/g \cdot K)(2\ K) = 1\ J$

$\Delta U = q + w = (1\ J) + (10\ J)$

$\boxed{\Delta U = 11\ J}$

1 1 **15 / 15**

- ✓ **+ 15 pts** **Correct, $$ \Delta U = 11 J$$**
- **+ 5 pts** $$w=\int Fdl = F \Delta l = 10 J$$
- **+ 5 pts** $$q=mC_s\Delta T = 1J$$
- **+ 5 pts** $$ \Delta U = q + w = 11J$$
- **- 3 pts** Math or unit error
- **+ 0 pts** Poor Scan/Did not follow instructions

Name: An Le, UID:

Problem #2

2) $Zn_{(s)} + H_2SO_{4\,(aq)} \rightarrow ZnSO_{4\,(aq)} + H_{2\,(g)}$

a) closed vessel of fixed volume $\rightarrow \Delta V = 0 \rightarrow V_f = V_i$

$W = -\int_{V_i}^{V_f} P\,dV \rightarrow -\int_{V_i}^{V_i} P\,dV = 0$ since $V_f = V_i$

$\boxed{W = 0\ J}$

b) an open beaker at $27°C = 300\ K$

$10\ g\ Zn \left| \frac{mol\ Zn}{65.38\ g\ Zn} \right. = 0.153\ mol\ Zn$

$W = -\int P\,dV = -\int \frac{nRT}{V}\,dV = -nRT\int_{V_i}^{V_f} \frac{1}{V}\,dV = -nRT\ln\left(\frac{V_f}{V_i}\right)$

Since volume of solid is negligible, ignore $\ln\left(\frac{V_f}{V_i}\right)$

$W = -nRT = -(0.153\ mol)(8.314\ J/mol\cdot K)(300\ K) = -381.613\ J$

$\boxed{W = -381.6\ J}$

2.1 2.i **5 / 5**

✓ **+ 5 pts** Correct $$w =0$$

**- 3 pts** Math or unit error

**+ 0 pts** Incorrect

Name: An Le, UID:

Problem #2

2) $Zn_{(s)} + H_2SO_{4\,(aq)} \rightarrow ZnSO_{4\,(aq)} + H_{2\,(g)}$

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$W = -\int_{V_i}^{V_f} P\,dV \rightarrow -\int_{V_i}^{V_i} P\,dV = 0$ since $V_f = V_i$

$\boxed{W = 0\ J}$

b) an open beaker at $27°C = 300\ K$

$10\ g\ Zn \left| \frac{mol\ Zn}{65.38\ g\ Zn} \right. = 0.153\ mol\ Zn$

$W = -\int P\,dV = -\int \frac{nRT}{V}\,dV = -nRT\int_{V_i}^{V_f} \frac{1}{V}\,dV = -nRT\,Ln\left(\frac{V_f}{V_i}\right)$

Since volume of solid is negligible, ignore $Ln\left(\frac{V_f}{V_i}\right)$

$W = -nRT = -(0.153\ mol)(8.314\ J/mol\cdot K)(300\ K) = -381.613\ J$

$\boxed{W = -381.6\ J}$

### 2.2 2.ii 14 / 15

✓ + **10 pts** **Correct, $$ w=-374J$$**

+ **4 pts** $$w=-\int P_{ex}dV = -P_{ex} \Delta V$$

+ **4 pts** $$\Delta V = V_f-V_i \approx V_f$$

✓ + **4 pts** **$$w = -P_{ex} \Delta V =-nRT$$**

+ **5 pts** $$w = \Delta U - q$$

- **3 pts** Math or unit error

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Name: An Le, UID:

Problem #3

3) $HN_{3(l)} + NO_{(g)} \rightarrow H_2O_{2(l)} + N_{2(g)}$

Balanced: $2HN_{3(l)} + 2NO_{(g)} \rightarrow H_2O_{2(l)} + 4N_{2(g)}$

i) standard enthalpy of the reaction

$\Delta H_{rxn} = H_{products} - H_{reactants}$

$= [(1 \text{ mol } H_2O_2)(-187.78 \text{ kJ/mol}) + (4 \text{ mol } N_2)(0 \text{ kJ/mol})]$

$- [(2 \text{ mol } HN_3)(90.25 \text{ kJ/mol}) + (2 \text{ mol NO})(264 \text{ kJ/mol})]$

$\boxed{\Delta H_{rxn} = -896.28 \text{ kJ/mol}}$

ii) This reaction is $\boxed{\text{exothermic}}$ because $\Delta H_{rxn} < 0$.

iii) $V = 1 \text{ L}$, $\Delta T = 5 \text{ K}$, $C_s = 4.2 \text{ J/g·K}$

↳ 1 L = 1000 g

$q_{water} = (1000 \text{ g})(4.2 \text{ J/g·K})(5 \text{ K}) = 21{,}000 \text{ J} = 21 \text{ kJ}$

$q_{rxn} = m \Delta H_{rxn}$

$(21 \text{ kJ}) = m(-896.28 \text{ kJ/mol})$ ignore ⊖, tells us exothermic

$m = 0.02343 \text{ mol } HN_3$

×2 (2 mol $HN_3$ in reaction)

$m = 0.04686 \text{ mol } HN_3 \rightarrow \boxed{0.047 \text{ mol } HN_3}$ needed to heat 1 L water by 5 K

3.1 3.i **10 / 10**

✓ **+ 10 pts** **Correct, $$\Delta H_{r}^o = -896.3 \frac {kJ}{mol}$$**

**+ 2 pts** $$ \Delta H_{r}^o = \Delta H_{f}^o(products)- \Delta H_{f}^o(reactants) $$

**+ 3 pts** $$ \Delta H_{r}^o = [\Delta H_{f}^o(H_2O_{2(l)})+4\Delta H_{f}^o(N_{2(g)})]-[2\Delta H_{f}^o(HN_{3(l)})+2\Delta H_{f}^o(NO_{(g)})] $$

**+ 2 pts** $$\Delta H_f^o(N_{2(g)})=0$$

**- 3 pts** Math or unit error

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## 3.2 3.ii **5 / 5**

- ✓ **+ 5 pts** **Correct, $$\Delta H_r^o<0$$, so exothermic**
- **+ 3 pts** $$ \Delta H_r^o >0$$, so endothermic

Name: An Le, UID:

Problem #3

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↳ 1 L = 1000 g

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### 3.3 3.iii **15 / 15**

- ✓ **+ 15 pts** **Correct, $$n_{NH_3}=0.046mol=0.04-0.05mol$$**
- **+ 3 pts** $$q_r=n_r \Delta H_r^o$$
- **+ 3 pts** $$q_w=mC_s \Delta T = 21 kJ$$
- **+ 3 pts** $$ q_w = -q_r$$ or $$ q_w+q_r=0$$
- **+ 3 pts** $$n_r=0.023mol=0.02mol$$
- **- 3 pts** Math or unit error

Name: An Le, UID:

Problem #4

4) $m_{ice} = 5\ kg$, $T_{ice} = -20°C = 253\ K$

$V_{water} = 100\ L\left(\frac{1000\ g}{1\ L}\right) = 100{,}000\ g$, $T_w = 70°C = 343\ K$

$q_w = -q_{ice}$

$q_w = (100{,}000\ g)(4.2\ J/g\cdot K)(T_{eq} - 343\ K) = (420{,}000\ J/K)(T_{eq} - 343\ K)$

$q_{ice} = m_{ice} C_{ice} \Delta T_{ice} + m_{ice} \Delta H_{fus} + m_{ice} C_w \Delta T_w$

$= (5000\ g)\left[(2.1\ J/g\cdot K)(273 - 253\ K) + (333\ J/g) + (4.2\ J/g\cdot K)(T_{eq} - 273\ K)\right]$

$= (5000\ g)\left[(42\ J/g) + (333\ J/g) + (4.2\ J/g\cdot K)(T_{eq} - 273\ K)\right]$

$= (1.875 \times 10^6\ J) + (21{,}000\ J/K)(T_{eq} - 273\ K)$

$420{,}000\ T_{eq} - (1.44 \times 10^8\ J) = -\left[(1.875 \times 10^6\ J) + 21{,}000\ T_{eq} - (5.733 \times 10^6\ J)\right]$

$441{,}000\ T_{eq} = 1.478 \times 10^8\ J$

$\boxed{T_{eq} = 335\ K}$

4 4 **20 / 20**

- ✓ **+ 20 pts** **Correct, $$ T_{eq}=335K$$**
- **+ 4 pts** $$q_i + q_w = 0$$ or $$ q_i = -q_w$$
- **+ 5 pts** $$q_i = m_iC_i \Delta T_i + m_i \Delta H_{fus}^o + m_iC_w \Delta T_w$$
- **+ 3 pts** $$q_i = m_iC_i  (273K-253K) + m_i \Delta H_{fus}^o + m_iC_w (T_{eq}-273K)$$
- **+ 2 pts** $$ q_w = m_wC_w \Delta T$$
- **+ 2 pts** $$ q_w = m_wC_w (T_{eq}-343K)$$
- **- 3 pts** Math or unit error

Name: An Le, UID:

Problem #5

5) i) $(P_i, T_i, V_i) \longrightarrow (P_f, T_f, V_f)$ by isothermal expansion ($\Delta T = 0$)

$\Delta U = \frac{3}{2} nR\cancel{\Delta T} = 0 \rightarrow \boxed{\Delta U = 0}$

$W = -\int_{V_i}^{V_f} P dV = -\int_{V_i}^{V_f} \frac{nRT}{V} dV = -nRT \int_{V_i}^{V_f} \frac{1}{V} dV$

$\boxed{W = -nRT \ln\left(\frac{V_f}{V_i}\right)}$

$\Delta U = q + w = 0 \rightarrow q = -w \rightarrow \boxed{q = nRT \ln\left(\frac{V_f}{V_i}\right)}$

ii) isochoric ($\Delta V = 0$) followed by isobaric expansion ($\Delta P = 0$)

$\Delta U_1 = \frac{3}{2} nR\Delta T_1$ $\Delta U_2 = \frac{3}{2} nR\Delta T_2$

$W_1 = -\int P d\cancel{V} = 0$ $W_2 = -\int P dV = -P\int dV = -P\Delta V$

$\Delta U = q + \cancel{w} = q_1 = \frac{3}{2} nR\Delta T_1$ $q_2 = nC_p \Delta T = n\left(\frac{5}{2}R\right)\Delta T = \frac{5}{2} nR\Delta T_2$

$\Delta U_1 + \Delta U_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{3}{2} nR\Delta T_2 = \Delta U}$

$W_1 + W_2 = 0 + (-P\Delta V) = \boxed{-P\Delta V = W}$

$q_1 + q_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{5}{2} nR\Delta T_2 = q}$

iii) In both parts (i) and (ii), work is negative and heat is positive. Negative work entails that the system is "losing" work, or rather it is doing work. Positive heat means that heat is gained. Considering we are looking at the expansion of a gas in both cases, negative work and positive heat both intuitively make sense.

5.1 5.i **10 / 10**

- ✓ **+ 10 pts** **Correct, $$\Delta U_T = 0$$, $$q_T=nRTln(\frac {V_f}{V_i})$$, $$w_T=-nRTln(\frac {V_f}{V_i})$$**
- **+ 3 pts** $$\Delta U_T = 0$$
- **+ 3 pts** $$q_T=nRTln(\frac {V_f}{V_i})$$
- **+ 4 pts** $$w_T=-nRTln(\frac {V_f}{V_i})$$

Name: An Le, UID:

Problem #5

5) i) $(P_i, T_i, V_i) \longrightarrow (P_f, T_f, V_f)$ by isothermal expansion $(\Delta T = 0)$

$\Delta U = \frac{3}{2} nR\Delta T = 0 \rightarrow \boxed{\Delta U = 0}$

$W = -\int_{V_i}^{V_f} P dV = -\int_{V_i}^{V_f} \frac{nRT}{V} dV = -nRT \int_{V_i}^{V_f} \frac{1}{V} dV$

$\boxed{W = -nRT \ln\left(\frac{V_f}{V_i}\right)}$

$\Delta U = q + w = 0 \rightarrow q = -W \rightarrow \boxed{q = nRT \ln\left(\frac{V_f}{V_i}\right)}$

ii) isochoric $(\Delta V = 0)$ followed by isobaric expansion $(\Delta P = 0)$

$\Delta U_1 = \frac{3}{2} nR\Delta T_1$ $\quad\quad$ $\Delta U_2 = \frac{3}{2} nR\Delta T_2$

$W_1 = -\int P dV = 0$ $\quad\quad$ $W_2 = -\int P dV = -P\int dV = -P\Delta V$

$\Delta U = q + w = q_1 = \frac{3}{2} nR\Delta T_1$ $\quad\quad$ $q_2 = nC_p \Delta T = n\left(\frac{5}{2}R\right)\Delta T = \frac{5}{2} nR\Delta T_2$

$\Delta U_1 + \Delta U_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{3}{2} nR\Delta T_2 = \Delta U}$

$W_1 + W_2 = 0 + (-P\Delta V) = \boxed{-P\Delta V = W}$

$q_1 + q_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{5}{2} nR\Delta T_2 = q}$

iii) In both parts (i) and (ii), work is negative and heat is positive. Negative work entails that the system is "losing" work, or rather it is doing work. Positive heat means that heat is gained. Considering we are looking at the expansion of a gas in both cases, negative work and positive heat both intuitively make sense.

5.2 5.ii **20 / 20**

✓ **+ 20 pts Correct, $$ \Delta U_V = \frac {3}{2}nR (T_2-T_i)$$, $$q_V= \frac {3}{2}nR (T_2-T_i)$$, $$w_V=0$$, $$ \Delta U_P = \frac {3}{2}nR (T_i-T_2)$$, $$q_P= \frac {5}{2}nR (T_i-T_2)$$, $$w_P=-P \Delta V=-nR (T_i-T_2)$$**

+ **4 pts** $$ \Delta U_V = \frac {3}{2}nR (T_2-T_i)$$
+ **3 pts** $$ q_V = \frac {3}{2}nR (T_2-T_i)$$
+ **3 pts** $$w_V=0$$
+ **4 pts** $$ \Delta U_P = \frac {3}{2}nR (T_i-T_2)$$
+ **3 pts** $$ q_P = \frac {5}{2}nR (T_i-T_2)$$
+ **3 pts** $$w_P=-P \Delta V=-nR (T_i-T_2)$$
- **- 2 pts** Answer not simplified or total process values not correct

Name: An Le, UID:

Problem #5

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$\Delta U = \frac{3}{2} nR\Delta T = 0 \rightarrow \boxed{\Delta U = 0}$

$W = -\int_{V_i}^{V_f} P\,dV = -\int_{V_i}^{V_f} \frac{nRT}{V} dV = -nRT \int_{V_i}^{V_f} \frac{1}{V} dV$

$\boxed{W = -nRT \ln\left(\frac{V_f}{V_i}\right)}$

$\Delta U = q + w = 0 \rightarrow q = -w \rightarrow \boxed{q = nRT \ln\left(\frac{V_f}{V_i}\right)}$

ii) isochoric ($\Delta V = 0$) followed by isobaric expansion ($\Delta P = 0$)

$\Delta U_1 = \frac{3}{2} nR\Delta T_1$ $\quad\quad$ $\Delta U_2 = \frac{3}{2} nR\Delta T_2$

$w_1 = -\int P\,dV = 0$ $\quad\quad$ $w_2 = -\int P\,dV = -P\int dV = -P\Delta V$

$\Delta U = q + w = q_1 = \frac{3}{2} nR\Delta T_1$ $\quad\quad$ $q_2 = nC_p\Delta T = n\left(\frac{5}{2}R\right)\Delta T = \frac{5}{2} nR\Delta T_2$

$\Delta U_1 + \Delta U_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{3}{2} nR\Delta T_2 = \Delta U}$

$w_1 + w_2 = 0 + (-P\Delta V) = \boxed{-P\Delta V = w}$

$q_1 + q_2 = \boxed{\frac{3}{2} nR\Delta T_1 + \frac{5}{2} nR\Delta T_2 = q}$

iii) In both parts (i) and (ii), work is negative and heat is positive. Negative work entails that the system is "losing" work, or rather it is doing work. Positive heat means that heat is gained. Considering we are looking at the expansion of a gas in both cases, negative work and positive heat both intuitively make sense.

## 5.3 5.iii 10 / 10

✓ **+ 10 pts Correct, $$ \Delta U_i=\Delta U_{ii}$$, $$q_i \ne q_{ii}$$, $$w_i \ne w_{ii} $$; $$q>0$$, so heat is being absorbed by the system; $$w<0$$, so work is being done by the system**

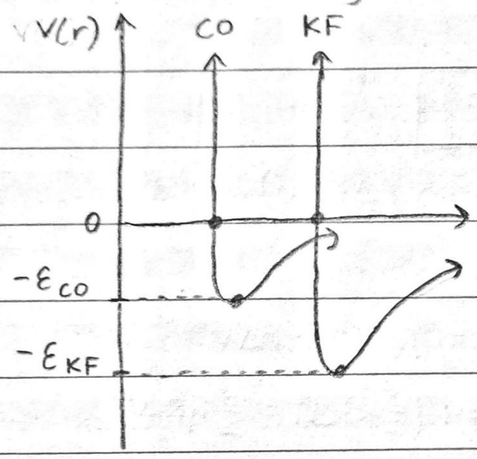
- **+ 3 pts** $$ \Delta U_i=\Delta U_{ii}$$, $$q_i \ne q_{ii}$$, $$w_i \ne w_{ii} $$
- **+ 4 pts** $$q>0$$, so heat is being absorbed by the system
- **+ 4 pts** $$w<0$$, so work is being done by the system
- **- 2 pts** $$q<0$$ or $$w>0$$ or $$w=0$$ or "it depends"
- **+ 2 pts** $$q>0$$, but no statement or incorrect statement of direction of exchange
- **+ 2 pts** $$w<0$$, but no statement or incorrect statement of direction of exchange
- **+ 2 pts** $$ \Delta U_i=\Delta U_{ii} = 0$$
- **+ 0 pts** Incorrect

Name: An Le, UID:

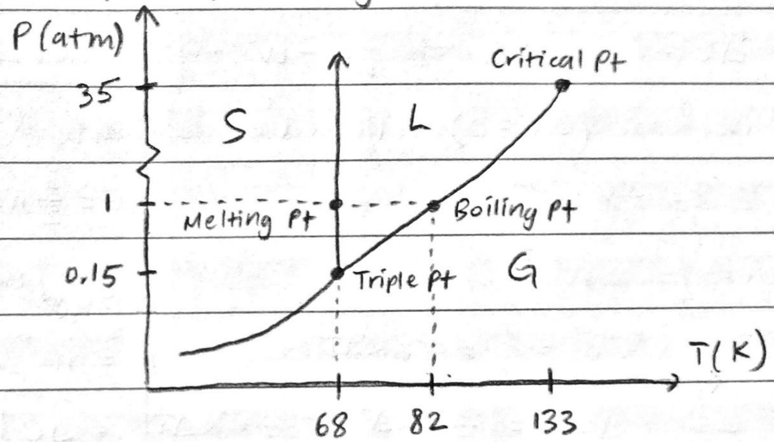
Problem #6

6) i) KF has stronger intermolecular forces than CO because KF is ionic while CO is polar with dipole-dipole forces. Ion-ion forces are inherently stronger than dipole-dipole forces.

ii)




iii) P-T phase diagram for CO




a) (0.15 atm, 50 K) → **solid**

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iv) 20 mol $CO_{(g)}$, $V = 1\ m^3$, $T = 300\ K$

$PV = nRT \rightarrow P = \frac{nRT}{V} = \frac{(20\ mol)(8.314\ J/mol \cdot K)(300K)}{(1m^3)} = 49,884\ Pa$

$P = \frac{F}{A} \rightarrow F = PA = (49,884\ Pa)(4.836\ m^2) =$ **$2.41 \times 10^5\ N$**

$V = 1\ m^3 = \frac{4}{3}\pi r^3 \rightarrow r = 0.62\ m \rightarrow A = 4\pi(0.62m)^2 = 4.836\ m^2$

v) $P = 1\ atm = 101325\ Pa$ $\quad PV = \underbrace{nRT}$ $\quad$ nRT constant

$P_1 V_1 = P_2 V_2 \rightarrow (49,884\ Pa)(1\ m^3) = (101325\ Pa)(V_2)$

**$V_2 = 0.49\ m^3$**

6.1 6.i **10 / 10**

- ✓ **+ 10 pts** **Correct, CO is polar and has dipole-dipole forces, KF is ionic; therefore, KF IMFs are stronger.**
- **+ 3 pts** CO is polar $$ \Delta EN_{CO}=0.9$$ and has dipole-dipole IMFs
- **+ 3 pts** KF is ionic $$ \Delta EN_{KF}=3.16$$ and has ionic or strong dipole-dipole IMFs
- **+ 3 pts** KF > CO IMFs
- **+ 0 pts** poor scan/did not follow instructions

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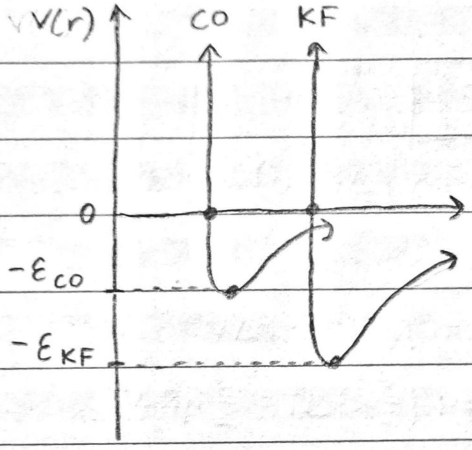


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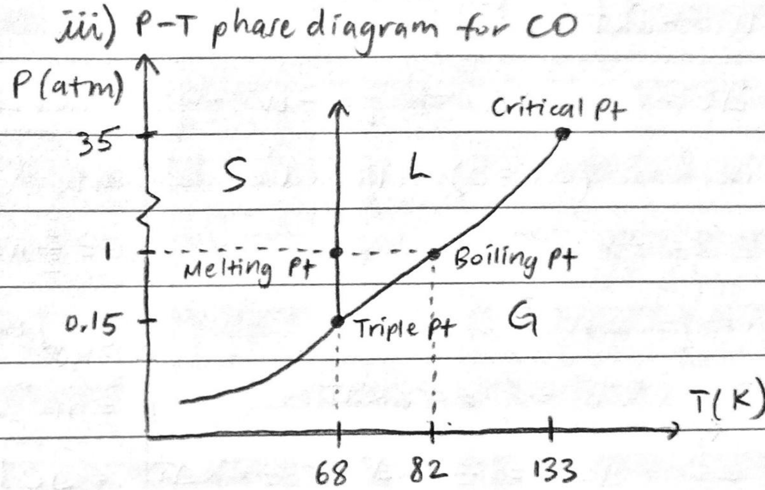


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$P_1V_1 = P_2V_2 \rightarrow (49{,}884\ Pa)(1\ m^3) = (101325\ Pa)(V_2)$

$\boxed{V_2 = 0.49\ m^3}$

6.2 6.ii **10 / 10**

✓ **+ 10 pts** **Correct**

- **+ 2 pts** Plot of $$ V(r) $$ vs $$ r $$
- **+ 2 pts** Correct general shape
- **+ 2 pts** KF has a deeper well because it has stronger IMFs
- **+ 2 pts** KF crosses the x-axis further from the origin because it is larger

Name: An Le, UID:

Problem #6

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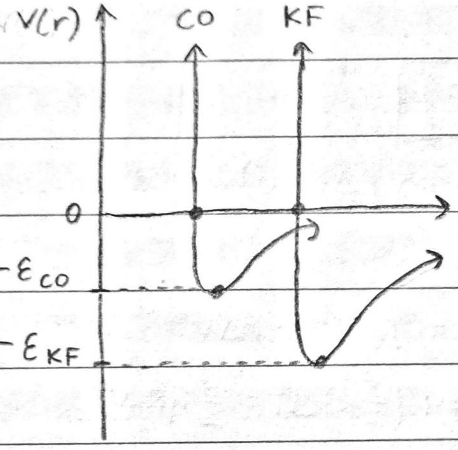


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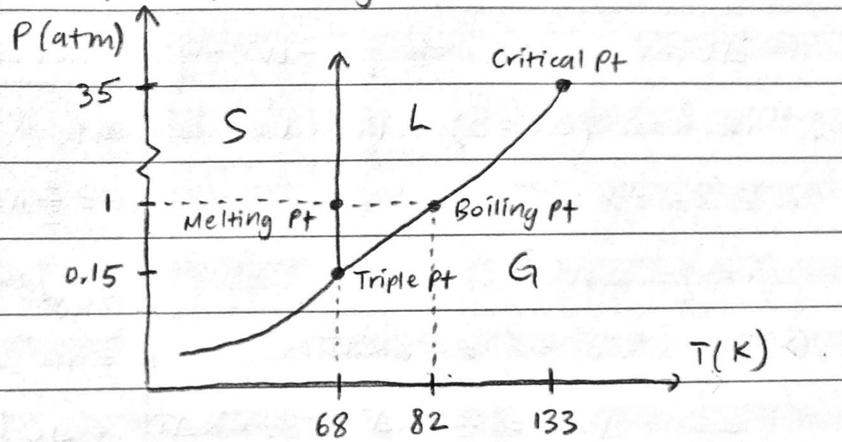


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$\boxed{V_2 = 0.49\ m^3}$

6.3 6.iii **12 / 12**

- ✓ **+ 12 pts** **Correct**
- **+ 3 pts** Plot of $$ P$$ vs $$ T $$
- **+ 3 pts** Correct shape
- **+ 2 pts** Point a: solid
- **+ 2 pts** Point b: The triple point, so solid, liquid and gas
- **+ 2 pts** Point c: The melting point, so solid and liquid

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Problem #6

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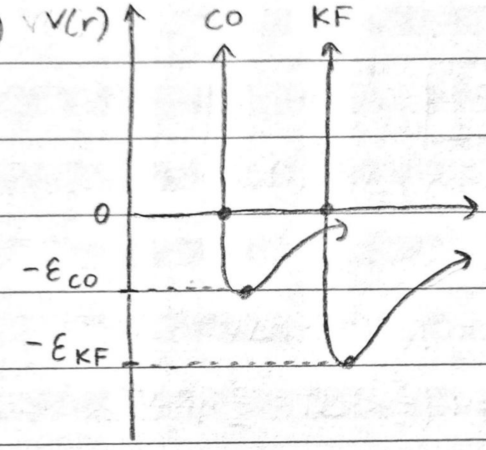


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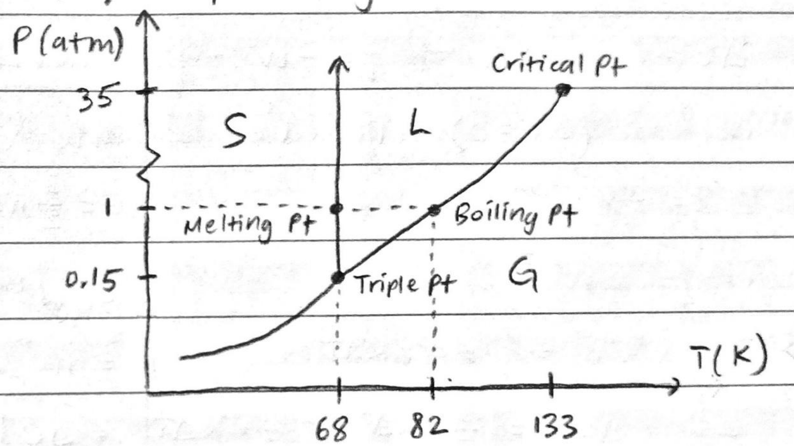


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$\boxed{V_2 = 0.49\ m^3}$

### 6.4 6.iv 10 / 10

- ✓ **+ 10 pts** **Correct, $$F=240.9kN=241kN$$**
- **+ 3 pts** $$r=0.62m$$
- **+ 2 pts** $$A=4.83m^2$$
- **+ 3 pts** $$ F=PA$$
- **- 3 pts** Math or unit error
- **+ 0 pts** No credit

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Problem #6

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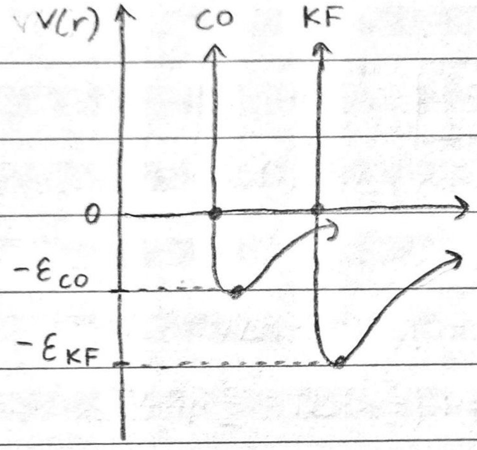
ii) 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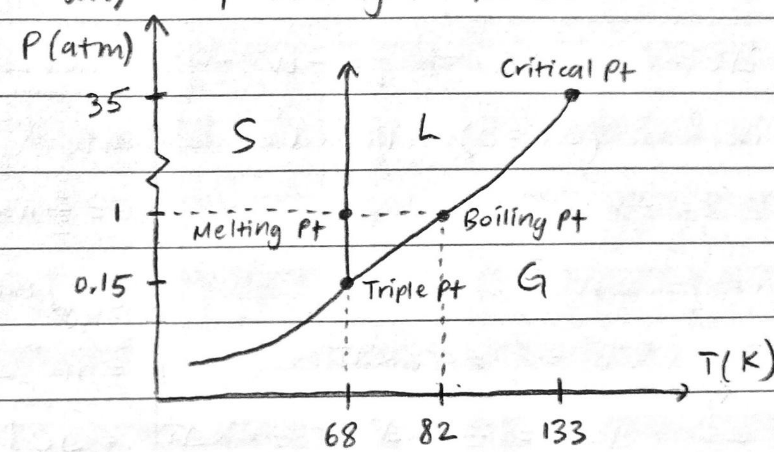


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$\boxed{V_2 = 0.49\ m^3}$

6.5 6.v **8 / 8**

✓ **+ 8 pts** **Correct, $V_{eq}=0.49m^3=0.5m^3$**

**+ 5 pts** At mechanical equilibrium, $P_{eq}=P_{atm}=1atm$

**- 3 pts** Math or unit error